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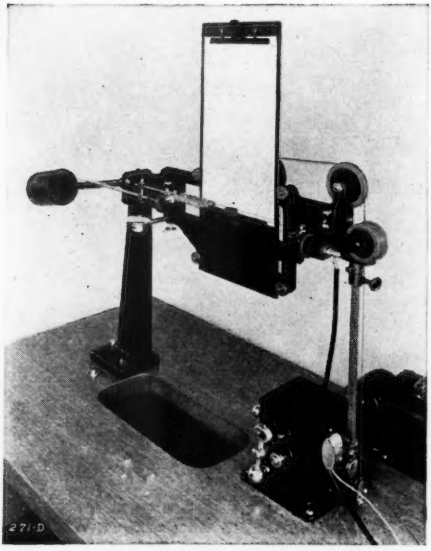

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Publication of Two Institute Researches

FOR the first time the Institute has the privilege of publishing the released reports of two of its researches in *Textile Research:* The eighth report of the completed research on "The Warp Sizing of Filament Viscose Rayon," and the first report of the research on "Textile Drying," now nearing completion. Subscribers to the latter study, now nearing the end of its third year at the National Bureau of Standards, have already received eight progress reports and two more are in preparation and will conclude the present phase of the work. It may be a year hence before all of these reports can be released for publication, but the warp sizing reports will be continued serially.

* * *

Two Theories of Cotton Cellulose Structure

THE Textile Foundation research report in this issue by Dr. Milton Harris and Charles W. Hock is far more important to all who are interested in cellulose structure than is indicated by the title: "Microscopic Examination of Cotton Fibres in Cuprammonium Solutions." Actually, it confirms the classic theory of cotton cellulose structure, and holds that the diminutive cellulose particles that Dr. Wanda K. Farr and associates have found held together in cuprammonium solution with a cementing material, are nothing but undissolved residue from raw or dewaxed cotton fibres, consisting principally of fragmented shells which formed the outer surface of the fibres, and to a lesser extent of material from the lumen. New technique developed by the authors, and preventing exposure of the reagent to the air, eliminates the isotropic particles. It will be appreciated that it is highly important to know which of these divergent theories is correct because measurements of the viscosity of cuprammonium hydroxide solutions of cotton are widely used to evaluate certain characteristics of the fibre.

* * *

"VICTORY Through Staple Fibre" was the heading of an article that appeared recently in Field Marshall Goering's newspaper, *The National Zeitung.* It emphasizes the fact that Germany is exceptionally dependent upon synthetic raw materials as an essential part of her war economy. This note in the *Silk Journal and Rayon World,* Manchester, Eng., is followed by the significant query: "Are we making the most practical use of our supplies of rayon and staple fibre in our national war effort?"

Viscose Rayon: Stress-Strain Properties

II. Effect of Rate of Load

By H. R. BELLINSON *

A Textile Foundation Publication

Abstract

The effect of varying the rate of load upon the strength, breaking stretch and load-stretch diagram of viscose yarn is described. Tests were made on an inclined-plane machine, in which the rate of increase of load is constant throughout any one test.

The strength increases as the rate of loading is increased.

$$S = 2.3R + K$$

where S is the breaking strength at rate of load R, and K is related to the inherent strength of the material. The breaking stretch appears to be unaffected by change in rate of load. The only portion of the load diagram which appears to be definitely affected by the rate of load at which the test is performed is the "elastic limit," which increases with the rate of loading.

Testing

Material.—These tests were performed on viscose yarn 150/42, manufactured by the North American Rayon Corporation.

Apparatus.—The apparatus of these tests is an inclined-plane testing machine. This machine has already been described.[1] In this machine the load is applied by a carriage sliding along an inclined track. The rate of application of load depends only on the weight of the carriage and upon the rate of inclination of the track. The latter is made constant in the design of the instrument and the mass of the carriage remains constant throughout any one test, so that the rate of load is constant throughout such a test.

* Research Assistant working under the direction of Edward R. Schwarz, Professor of Textile Technology, Massachusetts Institute of Technology, Cambridge, Mass.

However, the rate of loading may be varied between tests merely by altering the mass of the carriage—by adding or removing weights. The machine as purchased was provided with three weights, such that the capacities were 250, 500, and 1,000 grams. To provide additional values of capacities (which are directly proportional to the rate of load) it was necessary to manufacture additional weights. These weights should be readily attachable to the carriage and to each other. This could be obtained quite easily by means of hooks, but hooks are at a disadvantage in that the attachment is not rigid. Should the attached weights begin to swing, the load on the specimen will be affected by the direction of swing. Consequently, the weights should be attached rigidly. This was accomplished by designing the weights so that they screwed into the carriage or into each other.

Each weight was calibrated for the capacity and rate of load it added to the carriage, these values are proportional to the mass. The total rate of load is then simply the sum of the values for the carriage and all the weights added to it.

Atmospheric Conditions.—All tests were made in an air-conditioned laboratory maintained at standard temperature and humidity. Temperature varied between 69.4° and 70.1° F.; relative humidity between 64 and 66% during the tests.

Specimen Length.—All tests were made on specimens held between jaws 20 in. apart.

Sampling.—It was pointed out in the previous report [1] that each group (that is, the specimens at each rate of loading) should be equally representative of the entire amount of yarn being tested.

Two skeins were taken in succession from the cone. These two skeins are the material being tested. The skeins were cut open, providing 160 strands. From these 160 strands, specimens were selected at random for each group of tests.

It was also stated in the previous report that it was desirable to randomize the time of testing the individual specimens rather than to complete each group of tests before proceeding to the next. This was done in examining the effect of specimen length by changing the length after every test. In the present case, the time required to change the rate of load (remove and attach weights) between every specimen would have been so considerable that this procedure was not followed, and the group of tests at each rate of load was computed before the weight of the carriage was altered. As a result, differences may have been introduced into the averages of groups which may be due to factors other than the rate of load.

However, the order in which groups were tested was randomized and does not follow the order of increase or decrease of rate of load. Consequently, these errors cannot be expected to affect the average trend produced by rate of load (see Fig. 1) but may cause individual averages to depart from the curve representing this trend by more than they might otherwise do.

Results

The average breaking values are tabulated in Table 1, along with the number of specimens tested in each group, and the rate of load at which that group was tested.

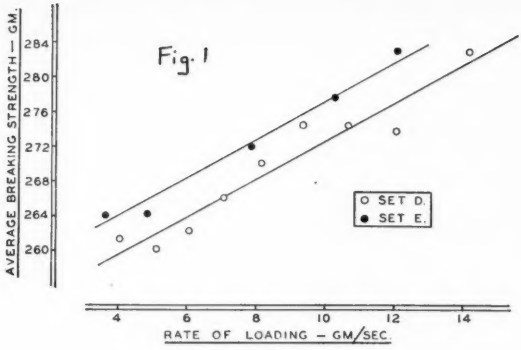

TABLE 1

Average Breaking Values: Set D

No. of Specimens	Rate of Load (gm/sec)	Strength (gm) Average	Strength (gm) Standard Deviation	Stretch (%) Average	Stretch (%) Standard Deviation
9	4.06	261.3	4.0	22.39	.51
9	5.14	260.2	5.5	22.03	.78
9	6.04	262.4	4.4	21.87	.65
10	7.07	266.1	3.9	22.02	.65
9	8.15	270.2	4.6	22.37	.60
10	9.36	274.7	2.2	22.60	.39
10	10.57	274.5	5.6	21.77	.64
9	12.06	273.9	4.1	22.19	.77
9	14.17	283.1	7.1	22.64	.51

Discussion

Strength.—The differences in average breaking strength are examined in Table 2 by the Analysis of Variance.[2]

TABLE 2

Analysis of Variance: Breaking Strength

Source of Variation	Sum of Squares	Degrees of Freedom	Variance
Within Groups	1,701.61	75	22.69
Between Groups	4,299.25	8	537.41
Total	6,000.86	83	

$$Z = 1.58$$

$$P < 0.001$$

The probability ($P < .001$) that these differences are merely sampling fluctuations is exceedingly small. The differences must certainly be real.

The correlation[3] between strength and rate of load is found to be + 0.814. This very high value is sufficient indication that the differences in breaking strength are due to the differences in rate of load.

The regression[4] equation relating average strength (S) with rate of load (R) is:

$$S = 2.22R + 250.76.$$

This equation is plotted as the lower straight line in Fig. 1. The circles represent the average values of each group of specimens. The upper line and the solid circles result from another series of tests (Set E). The regression equation was here found to be

$$S = 2.33R + 254.26.$$

In these equations, the constant term on the right is a measure of the average strength of the material. Sets D and E represent different samples of rayon; it is reasonable to find a difference in strength. At a testing rate of load of 10 gm./sec. (R = 10), the material of Set D would be expected to have an average strength of 272.96 grams, and Set E 277.56 grams. The difference is statistically significant, but indicates no more than that the two samples differ in strength.

The coefficient of R measures the effect of rate of load upon strength. The larger this coefficient the greater the effect. Since the material of the two sets is similar (both are 150/42 viscose yarn made by the North American Rayon Corporation), the effect should be the same. The difference between 2.22 and 2.33, when examined statistically,[5] is found to be not significant; that is, if the effect were the same, a difference of this magnitude might occur as a sampling fluctuation in samples of the present size. Therefore, it can be assumed that the effect is the same on both samples. The best value of the coefficient of R is 2.26, and the precision of this estimate is such that the true value is probably between 2.02 and 2.50.

Of course, the relation between strength and rate of load is not necessarily linear, as indicated in Fig. I and assumed in this discussion. However, the coefficient of correlation is a measure of how well a linear relationship fits the data. Therefore, the high value of correlation observed here is an indication that the true relationship is either linear or of only slight curvature. This applies only to the region investigated.

There is no evidence to show that the straight lines of Fig. 1 can be extrapolated, as straight lines, in either direction. Data could not be obtained at either lower or higher rates of loads with the present machine. At lower rates of loading, the maximum capacity of the machine would have been insufficient to break the yarn. At higher rates of load, the recorded stress-strain diagram becomes so flat that it is impossible to read it with any accuracy.

It should be noted that other writers have reported similar increases in strength with increased rate of loading. Haven[6] found the strength of cotton balloon cloth increased with rate of load. Schoffstall and Hamm,[7] and Hunter[8] have reported this effect in yarns.

Breaking Stretch.—As in the case of strength, the values of breaking stretch of Table 1 must first be examined by the Analysis of Variance.

TABLE 3

Analysis of Variance: Breaking Stretch

Source of Variation	Sum of Squares	Degrees of Freedom	Variance
Within Groups	29.5351	75	0.3938
Between Groups	7.4288	8	0.9286
Total	36.9639	83	

$$Z = 0.43$$

$$P \sim .03$$

The probability that the differences are merely sampling fluactuations is much greater than in the case of strength, but is still not so large that the observed differences may be attributed solely to sampling fluctuations. It appears likely that real differences in stretch occur among the groups.

However, the correlation between breaking stretch and rate of load is $r = + 0.138$. The probability that a value as large as this will occur as a sampling fluctuation when the true correlation is zero, is $P = .11$. Consequently, it is not safe to assume that correlation exists.

The Analysis of Variance indicates that real differences in breaking stretch may exist, but the correlation indicates that these differences are not associated with rate of load. A reasonable inference is that these differences result from something in the sampling or testing technique, perhaps from the fact that the group of tests at each rate of loading were completed before the new group was tested.

If the observed value of correlation is used to set up a regression equation, this equation is

$$E = 0.029R + 19.69,$$

where E is the average breaking stretch at rate of loading R. The coefficient of R measures the effect of rate of loading, but the precision of the estimate is such that the true value of this coefficient lies between $-.017$ and $+.076$. Thus, on the basis of the available data, the coefficient might be zero, and it is therefore unsafe to assume that the rate of loading has any effect upon the breaking stretch.

Load-stretch Diagram.—In Fig. 2 are shown the load-stretch diagrams obtained at four different rates of loading. Each of these curves is the average of the nine or ten tests performed at that rate of load.

The load-stretch diagram of viscose yarn consists of three portions with ill-defined boundaries. For low values of load, the yarn is elastic; in this region the diagram is a straight line. The inclined plane machine is not sufficiently sensitive to prove that the diagram is straight here, but Steinberger[9] found, in the case of single fibres, that this portion of the diagram was straight. The "elastic region" is terminated by a region, beyond which the rate of stretch is increased in a region of "strain hardening." The starting point is not sharply defined, and it is not possible to associate it with a precise value of load or of elongation.

The stretch at 75 grams load (near the end of the elastic region) is slightly less than 1%, corresponding to an extension of less than 0.2 in. in

a 20-in. specimen. The width of the line produced by the recording mechanism is about .02 in., but the position is probably not good to that value. The sensitivity is perhaps .04 in., and this is 20% of the actual stretch at 75 grams. There is an indication in the original data, that the slope of this elastic region (the slope being proportional to the modulus of elasticity) increases as the rate of load increases. However, the maximum difference appears to be of the order of 20%, and since this is of the same

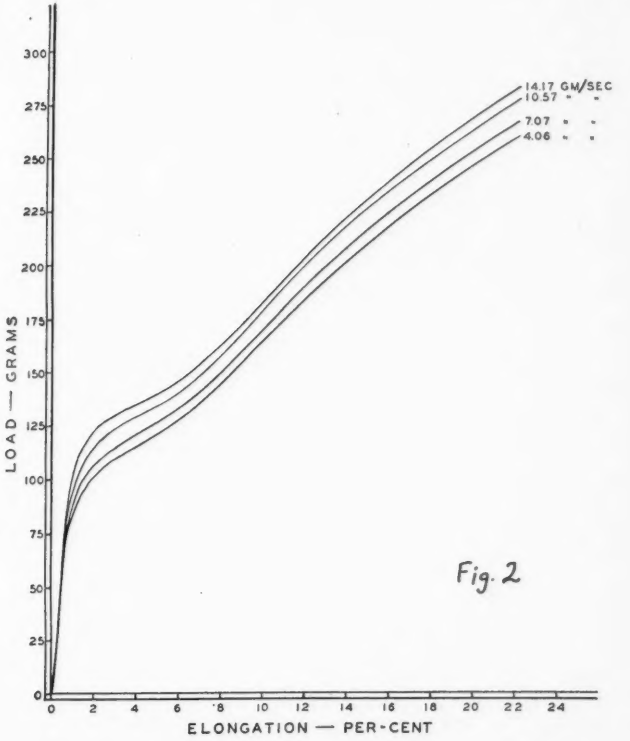

Fig. 2

order of magnitude as the sensitivity of the apparatus, no weight can be placed on the evidence. Consequently in Fig. 2, the four curves are shown as having the same modulus of elasticity. This point requires examination with apparatus more sensitive to small extensions.

Examination of Fig. 2 shows that the region of "strain hardening" is quite similar at all rates of loading, but that there are differences in the immediately preceding "yield region." The effect cannot be measured quantitatively, but obviously, as the rate of load is increased, the start of the

"yield region" rises. The increase, in fact, appears to be of the same order of magnitude as the increase in strength.

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* * *

THAT "shiners" or warp streakiness in woven rayon fabrics cannot safely be credited solely to uneven yarn is known to experienced technicians, yet few realize the varied faults of this character that can be caused by loom reeds and harnesses during weaving. They are explained and illustrated in a paper by M. M. Taylor of British Celanese, Ltd., in the December, 1939, issue of *The Journal of the Textile Institute.*

Microscopic Examination of Cotton Fibres in Cuprammonium Hydroxide Solutions

By CHARLES W. HOCK and MILTON HARRIS *

A Textile Foundation Publication

Abstract

It has been known for nearly a century that cuprammonium hydroxide solutions have a pronounced effect upon the cell walls of plants. Many investigators have observed, for example, that when cotton fibres are treated with this reagent, the bulk of the fibre appears to be dissolved, thereby producing a viscous solution from which cellulose can be precipitated by various means. The solubility of cellulose under these conditions has been utilized industrially in the manufacture of artificial textile fibres, and also in the laboratory as a means of evaluating the quality of the fibre, especially as regards tensile strength.

There are two different points of view concerning the behavior of the cellulose fibres when treated with cuprammonium hydroxide solutions. According to one group of investigators the cellulose of the cotton fibres does not dissolve in the reagent but maintains a visible state of aggregation in the form of diminutive particles, each of which is surrounded by cementing material which swells in cuprammonium solutions, thereby giving rise to a gel-like structure upon which many of the characteristic properties of the dispersion depend. The other group of investigators has supported the view that cellulose is dissolved in cuprammonium hydroxide, and that properties of the solutions, such as viscosity, are functions of the chain-length of the cellulose molecule.

Since the above viewpoints lead to widely different interpretations of the behavior of cotton in this solution, it appeared advisable to undertake a new investigation of the microscopically observable changes which cotton fibres undergo in this reagent.

It was found that during the treatment of cotton with cuprammonium hydroxide solutions, the cellulose dissolves, leaving residues which vary in amount and in structure

* Research Associates at the National Bureau of Standards representing the Textile Foundation.

depending upon the degree of purification of the fibres. The undissolved residue from raw and from dewaxed fibres consists principally of fragmented shells which formed the outer surface of the fibres, and to a lesser extent of material from the lumen. Both of these residues are isotropic and stain deeply with ruthenium red. Fibres from which both wax and pectic substance have been removed dissolve in cuprammonium reagent, leaving only a very small amount of isotropic residue which exhibits no definite cytological structure.

When a steady flow of cuprammonium hydroxide solution is applied to fibres mounted on a slide, the initial swelling of the fibres is followed by the appearance of small ellipsoidal particles which range from 1–2 μ in size, appear bright between crossed nicols, and become dark in color when stained with iodine and sulfuric acid. Identical particles appear, however, when cuprammonium hydroxide solution is drawn under the coverglass, in the absence of fibres. These particles, which result from the exposure of the cuprammonium hydroxide reagent to the air, are then washed under the coverglass where they become intimately associated with the fibre residue. Formation of these particles may be prevented by using a specially constructed cell which prevents exposure of the reagent. Under these conditions, no particles were observed during the slow passage, even for prolonged periods, of the cuprammonium reagent over the cotton fibres.

Introduction

THE viscosity of cuprammonium hydroxide solutions of cotton has frequently been related to the quality of the fibre, especially as regards tensile strength. It has been shown, for example, that chemical treatments which modify the properties of the fibres in such a way as to impair their tensile strength also bring about a lowering of the viscosity in cuprammonium hydroxide solutions.[1, 2] On the basis of the molecular chain theory for the structure of cellulose this decrease in tensile strength and the accompanying increase in cuprammonium hydroxide fluidity may be regarded as having resulted from a shortening in chain-length of the cellulose molecule. Recently, Farr and her collaborators[3, 4, 5] have brought forth a new explanation based principally on microscopic observations. According to these investigators, the cellulose component of cotton fibres does not dissolve in cuprammonium solution but maintains a visible state of aggregation in the form of diminutive cellulose particles, each of which is surrounded by cementing material which swells in cuprammonium solutions, thereby giving rise to a gel-like structure upon which many of the characteristic properties of the dispersion depend. On the basis of this interpretation it follows that the reduction of viscosity through processing or deterioration of the fibres may be regarded as the result of a direct effect upon the viscosity-producing power of the cementing material.

Since measurements of the viscosity of cuprammonium hydroxide solutions of cotton are widely used to evaluate some of the characteristics of

the fibre, and since the above concepts lead to widely different interpretations of the behavior of cotton in this solution, it appeared advisable to undertake a new investigation of the microscopically observable changes which cotton fibres undergo in this reagent.

Materials

The cotton used in these experiments was *Gossypium hirsutum* L, Missdel-7 variety, grown at the Delta Experiment Station at Stoneville, Miss., and furnished by the Bureau of Agricultural Economics, U. S. Department of Agriculture. It had been ginned and twice carded, but had received no chemical treatments. In the present paper these fibres are designated as *raw fibres.* The natural waxes were removed from the raw fibres by extraction with alcohol and ether for 24 hours each. These fibres are termed *dewaxed fibres.* A portion of the dewaxed material was further purified by extraction for six hours with a boiling 1% solution of sodium hydroxide, according to the method recommended for the preparation of standard cellulose. The procedure was essentially the same as that described by Corey and Gray,[6] except that the apparatus of Worner and Mease[7] was employed. Fibres treated in this way were shown by the method of Whistler, Martin, and Harris [8] to be free of pectic substance. These fibres from which both wax and pectic substance were removed, are designated *depectinized fibres.*

Two solutions of cuprammonium hydroxide were used in the experiments. One, made according to the recommendations of Mease,[9] is essentially the same as that set forth by the Fabrics Research Committee (London)[10] except that the higher concentration of ammonia originally recommended by Clibbens and Geake [11] was used. This solution contained 240 ± 5 g. of ammonia (NH_3), 15 ± 0.1 g. of copper, and 1.0 g. of sucrose per liter. The concentration of nitrite was less than 0.5%. In the present paper this solution will hereafter be referred to as *cuprammonium hydroxide solution A.* A second cuprammonium hydroxide solution, prepared according to the specification of the Division of Cellulose Chemistry of the American Chemical Society [12] was also used. It contained 30 ± 2 g. of copper, 165 ± 2 g. of ammonia and 10 g. of sucrose per liter. In the present paper this solution will hereafter be referred to as *cuprammonium hydroxide solution B.* When not in actual use, all solutions of cuprammonium hydroxide were kept under nitrogen in tightly stoppered bottles in the refrigerator. Unless stated otherwise, both solutions A and B were used in each of the experiments in this investigation.

Experimental Procedure and Results

Raw, dewaxed, and depectinized fibres were placed, without any mounting medium, on microscope slides, and then examined microscopically as cuprammonium hydroxide solution was drawn under the coverglass. In other cases the fibres were mounted in distilled water, or in ammonium hydroxide, and the cuprammonium solution was added as above. The water and ammonium hydroxide appeared to act merely as diluents, thereby retarding the solvent action of the cuprammonium hydroxide solution. The behavior of the fibres in the cuprammonium reagent was observed microscopically using ordinary and dark-field illumination, and crossed nicols.

Raw cotton fibres, upon addition of the reagent, immediately began to swell and twist, often forming balloon-like structures (Fig. 1, A and B). After a few minutes the inner portion of the fibre appeared to be completely dissolved, leaving transparent shells which originally formed the outer surface of the fibres (Fig. 1, C). Likewise, a small amount of material from the lumen did not dissolve (Fig. 1, B). This behavior was especially striking when observed with crossed nicols. The fibres, originally bright against a black background, became dimmer as the cellulose was dissolved by the reagent. After a few minutes the field was black, which indicated that all birefringent material had disappeared. When the same preparation was then examined in ordinary light, it was found to contain many of the shells described above.

Dewaxed cotton fibres presented essentially the same picture as raw fibres. Dissolution of the inner part of the fibre took place in a few minutes, leaving residues (Fig. 2), similar to those of the raw fibres (Fig. 1, C), but less dense and bulky, and often more torn and fragmented than the latter. With crossed nicols the results were the same as with raw cotton; that is, the strongly birefringent cellulose was dissolved rapidly, leaving an insoluble, isotropic material.

Depectinized cotton fibres dissolved in cuprammonium hydroxide solution, leaving only a very small amount of isotropic residue which consisted of small irregular bits of material (Fig. 3). This residue exhibited no definite cytological structure such as that shown by the shells of raw and of dewaxed fibres. Compare with Figs. 1, C and 2.

The isotropic shells of raw and of dewaxed fibres, and the isotropic material from the lumen, did not stain blue when given the iodine-sulfuric acid test for cellulose, but stained deeply with ruthenium red.[13] Although ruthenium red is not a specific stain for pectic substance, native pectic compounds invariably take a red color in the presence of this dye.[14]

In the above experiments the effects of cuprammonium reagent on the different samples of cotton could be observed for only relatively short periods. In order to make observations over longer periods, samples of raw, dewaxed, and depectinized cotton fibres were placed in separate vials of cuprammonium hydroxide solution. At intervals thereafter, samples from each of the vials were removed and viewed microscopically, using ordinary and dark-field illumination, and crossed nicols. During the first day the preparations were examined every few hours; during the remainder of the first week, examinations were made once each day, and thereafter once each week for a period of six weeks. After the initial dissolution of cellulose, which appeared to be complete in a few minutes, there was no further change in microscopic appearance of the undissolved material. The solutions of raw and of dewaxed cotton showed nothing but isotropic residues, while the samples containing depectinized cotton were practically free of residue.

These experiments indicate that pectic substance is a constituent of the insoluble shells which remain when cotton fibres are treated with cuprammonium hydroxide solutions. This conclusion is substantiated by direct chemical evidence presented elsewhere.[2] It also appeared from these experiments that the cellulose portion of the fibres dissolved in cuprammonium reagent, leaving no microscopically resolvable particles of the type described by Farr,[3] who has stated, however, that the particles are not visible as ordinarily observed since they are obscured to the point of in-

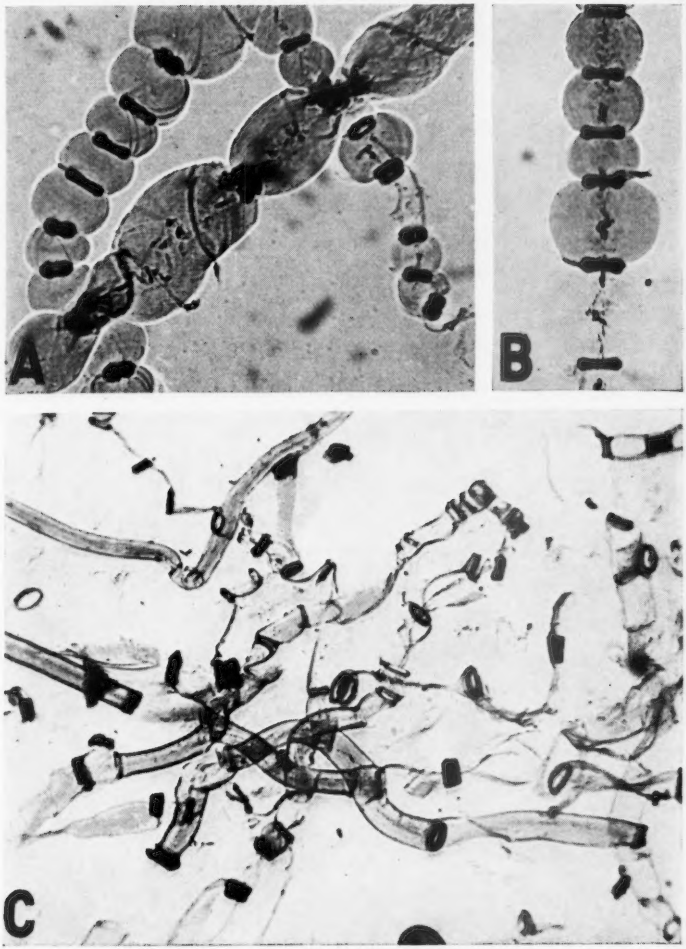

Fig. 1.—Raw cotton fibres in cuprammonium hydroxide solution. (A) Fibres swollen to form "balloons." (B) Typical string of "balloons," showing deeply-stained material in the lumen and at the constrictions between the swellings. (C) Residue which remains after the cellulose of the fibres has dissolved in the reagent.

Fibres stained with ruthenium red. (Magnification 120 ×)

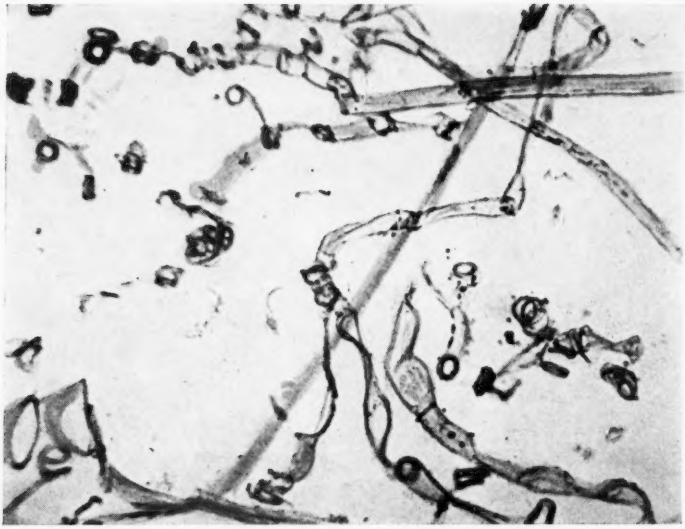

Fig. 2.—Dewaxed cotton fibres in cuprammonium hydroxide solution. Residue which remains after the cellulose of the fibres has dissolved in the reagent.
Fibres stained with ruthenium red. (*Magnification 120 ×*)

Fig. 3.—Depectinized cotton fibres in cuprammonium hydroxide solution. Residue which remains after the cellulose of the fibres has dissolved in the reagent.
(*Magnification 120 ×*)

visibility by a matrix of colloidal cementing material which surrounds them. It is stated further that by maintaining a steady flow of cuprammonium hydroxide over the fibres the matrix may be removed, thereby rendering the particles visible. It might have been expected, however, that the particles would have been visible in the depectinized fibres since these fibres left an almost negligible amount of visible colloidal material after treatment with cuprammonium reagent.

Since this was not the case, it appeared advisable to repeat Farr's experiments exactly as they are described. Raw cotton fibres were mounted in distilled water. The water was then gradually replaced with cuprammonium hydroxide solution by the following procedure: Small drops of the reagent were applied to one edge of the coverglass. The solution was then drawn under the coverglass by means of very narrow strips of filter paper placed at the opposite side. Swelling of the fibres ensued, resulting in the formation of some "balloons" (Fig. 1, A and B) which eventually disappeared leaving residues like those described earlier. However, as the flow of fresh reagent was continued, small particles appeared (Fig. 4, A).

The same technique was then applied to depectinized cotton fibres. As previously described, the cellulose appeared to dissolve upon addition of the cuprammonium hydroxide, leaving only a very small amount of insoluble residue. Nevertheless, as with raw fibres, particles became evident when a steady flow of the reagent was maintained.

It was noted, however, that identical particles appeared, even in the absence of fibres, when the steady flow of cuprammonium hydroxide was continued. The results were the same whether cuprammonium solution A or B was used. In both cases the particles appeared to be ellipsoidal and ranged from 1–2 μ in size. They were birefringent and showed extinction when rotated between crossed nicols. When given the iodine-sulfuric acid test for cellulose, dark particles, somewhat larger than the original ones, were observed. The photomicrographs (Figs. 5, B, 6, A and B) of these particles greatly resemble those shown by Farr.[3] All of these photomicrographs are of cuprammonium hydroxide solutions *which contained no cotton fibres.* In all cases the original solutions were clear (Fig. 5, A), and particles appeared only after the solution was exposed to the air, as in drawing it under the coverglass.

Further examination of the cuprammonium solutions showed that a precipitate was always formed when this reagent was exposed. Farr[3] has stated that a steady flow of the solution had to be maintained in order to prevent crystallization of the copper salt. In the present investigation it was found that regardless of the care exercised in this experiment, particles were always obtained when the cuprammonium solution was allowed to flow under the coverglass according to the described technique.

The experiments in which a continuous flow of cuprammonium reagent was maintained over the fibres were then repeated under conditions which prevented exposure of the reagent to air. In order to do this a sealed mount, constructed as follows, was employed: A ring consisting of a mixture of paraffin and vaseline was made in the center of a microscope slide, and a few cotton fibres were then placed in the inclosure. A hypodermic syringe was arranged in such a way that the tip of the needle extended just inside the ring, on the opposite side of which a small opening was made. A coverglass was then placed over the fibres and the ring, and

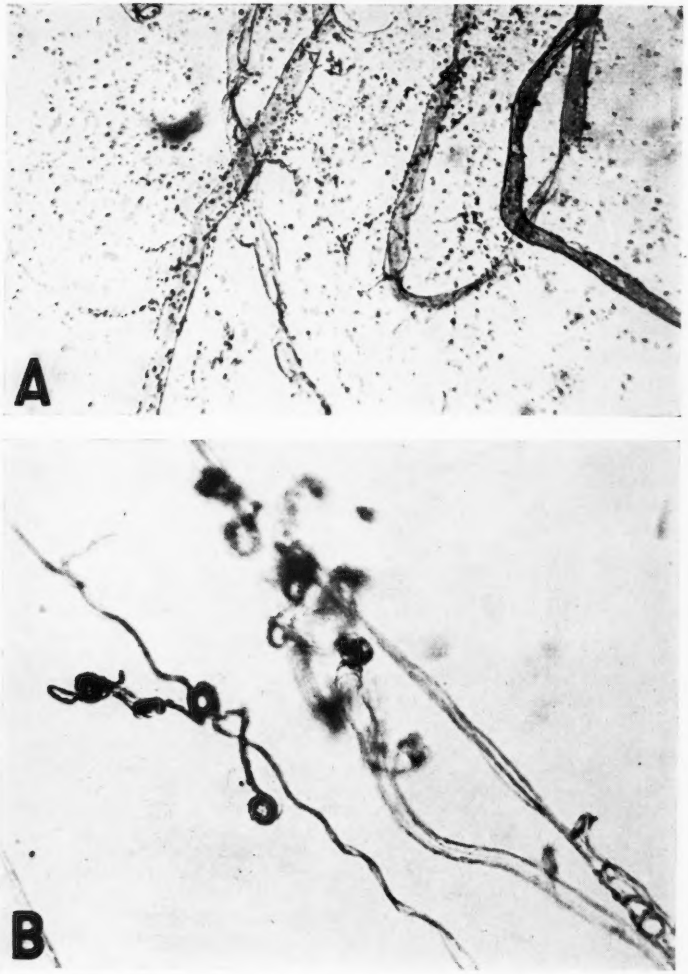

Fig. 4.—Fibres treated with a steady flow of cuprammonium hydroxide solution. (A) Residue of raw fibres after a continuous flow of the reagent was maintained over them. Particles, formed from the cuprammonium solution, are seen among the residue. (B) Raw cotton fibres after treatment with cuprammonium solution for one hour, under conditions which prevented exposure of the reagent.

(*Magnification 120 ×*)

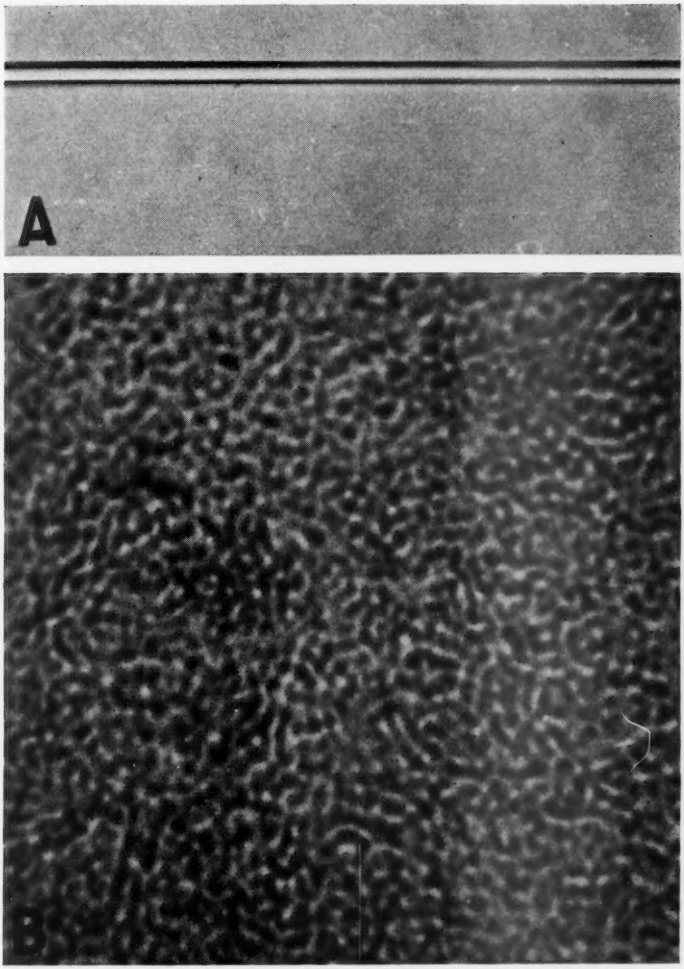

Fig. 5.—Cuprammonium hydroxide solution: no cellulose present. (A) Fine strand of glass rod in focus in the solution. The latter has not been exposed to allow formation of particles. (B) Particles formed upon exposure of the reagent to air.

(*Magnification: A, 500 ×; B, 1500 ×*)

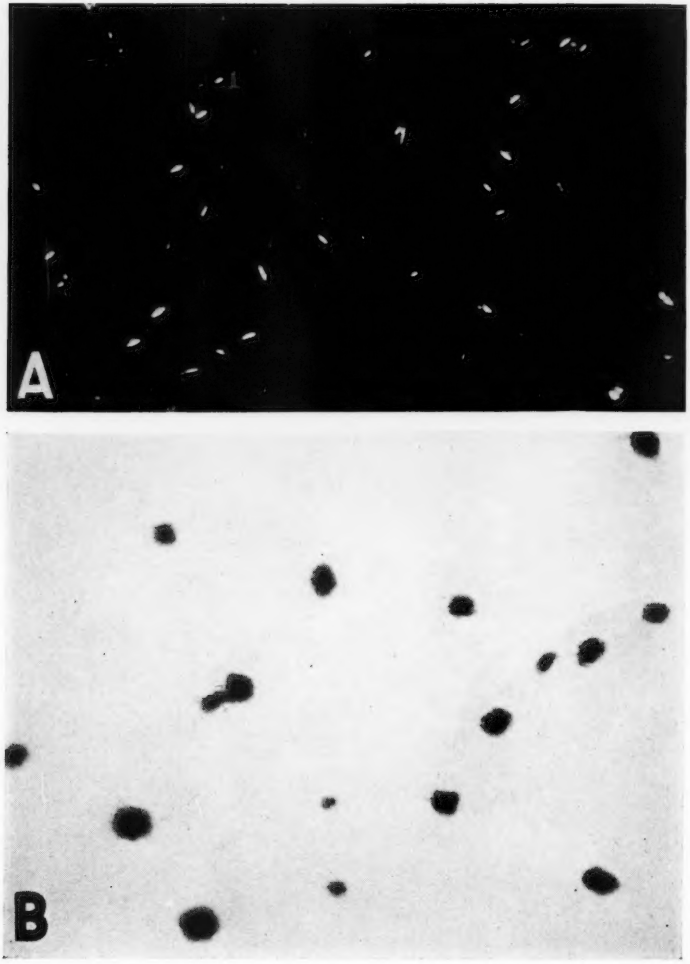

Fig. 6.—Particles formed in cuprammonium hydroxide solution, in the absence of cellulose. (A) Particles as viewed between crossed nicols. (B) Particles which appear after the addition of iodine and sulfuric acid.

(Magnification 1500 ×)

further sealed to the slide by applying to the edges of the coverglass a viscous solution of methyl methacrylate in acetone. The microscope slide and syringe were fastened to a sheet of stiff cardboard so that the whole apparatus could be placed on the stage of the microscope.

The syringe was filled with cuprammonium hydroxide solution. By applying pressure to the plunger of the syringe, the solution was passed slowly over the fibres, which were mounted either dry or in distilled water. The liquid was allowed to flow through the cell and out the small opening in the ring. During this process the behavior of the fibres was continuously observed with the microscope.

Using this specially constructed cell which prevented exposure of the reagent, fibres were treated with cuprammonium hydroxide solutions A and B. It was found that a steady flow of solution A could be passed over the fibres for more than an hour without the appearance of particles (Fig. 4, B). As the reagent started to flow through the cell the frequently observed reaction took place. The fibres began to swell, thereby giving rise to typical balloon-like structures which eventually appeared to be optically clear. Moreover, as the flow of cuprammonium hydroxide was continued, no particles appeared even after prolonged passage of the reagent.

When solution B was used, some particles always appeared even in control mounts which contained no fibres. In all cases in which the solutions were exposed to the air, particles formed more readily with solution B than with A, probably because of the higher copper and lower ammonia concentrations of the former. Because of this fact, solution A was found to be much more desirable for microscopic studies of the behavior of cotton fibres in cuprammonium reagent.

The results of this investigation indicate that microscopically resolvable particles of cellulose do not persist when cotton fibres are dispersed in cuprammonium hydroxide solutions. Particles are obtained, however, even in the absence of fibres upon exposure of the reagent to air.

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Equipment for Conditioning Materials at Constant Humidities and Elevated Temperatures

By JAMES G. WIEGERINK *

A Research of U. S. Institute for Textile Research, Inc.

Abstract

Equipment is described for the study of the moisture relations of materials in air of controlled relative humidities at elevated temperatures. The air is brought to the desired relative humidity and temperature by an arrangement including a saturator and automatically controlled heaters and then passed through a working chamber in which the materials to be studied can be weighed rapidly and accurately. Provision is made for measuring the rate of flow of air and for accurately determining the relative humidity in the working chamber.

The equipment has been used at temperatures from 96° F. to 300° F., relative humidities from 10% to 90% for temperatures up to 212° F. and to the maximum relative humidities obtainable at atmospheric pressure for temperatures between 212° F. and 300° F. The temperature in the working chamber can be maintained constant within ± 0.4° F. and the relative humidity within ± 1% relative humidity for experimental runs of several days' duration.

Data are given illustrating the performance of the equipment.

Introduction

The first step in an investigation of the drying of textiles co-operatively undertaken by the National Bureau of Standards and the United States Institute for Textile Research was to design and build equipment in which samples could be dried under known conditions of atmospheric humidity, temperature, and airflow. Since the equipment was planned for a study of eight or more different kinds of textiles, it was decided to provide sufficient capacity to condition 18 samples simultaneously under each drying condition. It was necessary for the equipment to be large enough

* Research Associate for the United States Institute for Textile Research at the National Bureau of Standards, Washington, D. C. The establishment of this Research Associateship was made possible by funds contributed by fifty-seven subscribers.

to accommodate various sizes of samples and to provide a relatively large ratio of volume of chamber to volume of samples in order to insure uniform treatment through each sample and for the different samples. It was particularly desirable to be able to weigh the samples rapidly and conveniently while they were in the apparatus. Temperatures up to 300° F. and the relative humidities corresponding to a water vapor pressure equal to 90% of normal atmospheric pressure can be maintained in the conditioning chamber.

The construction and operation of the equipment are described in this paper. The equipment has been in use for two years and has been found to be very satisfactory.

Description of Equipment

General.—The equipment consists of four principal parts shown in Fig. 1. Air enters the apparatus at A, is heated to a predetermined temperature in the pipe heater B, and enters a saturating chamber SC where it passes over the surface of water maintained at this temperature by a sur-

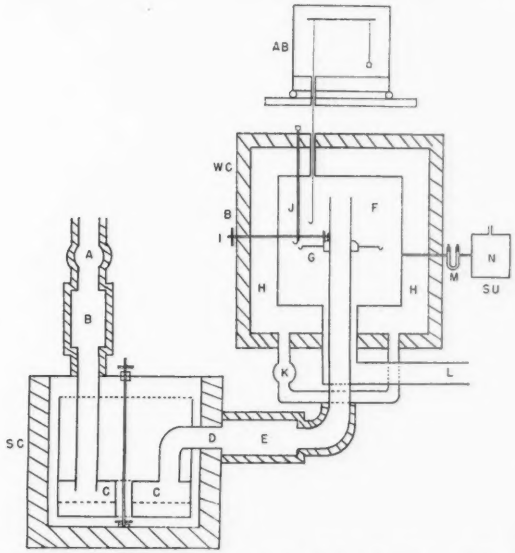

Fig. 1.—(SC) Saturation chamber. (WC) Working chamber. (AB) Analytical balance. (SU) Sampling unit.

(A) Air propeller. (B) First preheater. (C) Water chamber: water kept at 3″ depth: equipped with series of baffles for directing air through definite path. (D) Air outlet from conditioner. (E) Second preheater. (F) Working chamber. (G) Sample support. There are 18 of these arranged radially. (H) Air chamber. (I) Drive for rotating sample supports. (J) Mechanism for transferring sample from support to balance hook. (K) Air circulator. (L) Air outlet from working chamber. (M) Drying tube. (N) Wet gas meter.

rounding oil bath. This air after prolonged recirculation becomes saturated to a constant degree with water vapor at this temperature, is delivered to the working chamber WC maintained at some higher temperature. The textile samples exposed to this air in WC are weighed from time to time while approaching equilibrium, on the analytical balance AB. SU is a sampling unit for gravimetrically determining the relative humidity in WC. Provision is made for the adjustment and automatic control of temperatures in SC and WC, and for insulating the duct E between these two chambers to prevent condensation of moisture. The relation between the vapor pressure of water in the bath SC to that of water at the temperature of WC approximately determines the relative humidity of the air in this chamber, modified to some extent by the rate at which air flows through SC. The exact humidity maintained in WC depends upon the temperature control of both SC and WC, together with the airflow.

Saturator.—The air intake A is through the blower shown at the top center of Fig. 2. The rate of airflow through the equipment is kept constant by means of a blower driven by a 220 v a-c 1/20 hp. synchronous motor. The airflow may be changed by adjustment of dampers in the inlet and outlet sides of the blower. For most of the experimental runs a constant airflow of about 2½ cu. ft. per minute was used. At this rate, the air in the working chamber changes about every minute which removes the water practically as fast as it is given off by the samples.

The large section B of the insulated vertical pipe for preheating the air is shown in Fig. 2. This brass pipe is 3″ in diameter at the inlet and 6″ in diameter where the heaters are located. It contains two electric heaters, each with a maximum capacity of 330 watts. The temperature of the

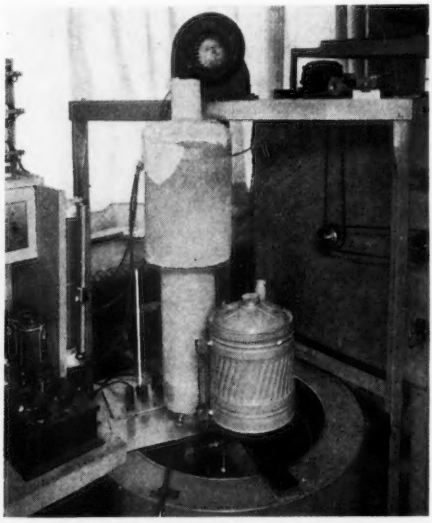

Fig. 2.—Air saturating equipment.

air leaving this preheater is regulated to approximate the temperature of the oil bath. This condition is checked by comparison of thermocouples, one of which is placed in the preheater, the other in the oil bath. The air then passes downward into the chamber C which is set in the oil bath.

The oil bath shown in Fig. 2, 22″ diameter and 20″ high, is cylindrical, made of heavy gage tinned copper, and insulated with four inches of fibre board. The outside covering of the oil bath is made of heavy gage sheet iron. This bath is heated by means of two 500-watt immersion heaters. One of these is connected with an automatic control system consisting of a mercury thermoregulator and relay. The other auxiliary heater is for quickly heating the bath to a desired temperature. The oil is circulated in the bath by a motor-driven propeller in such a manner that the oil is pulled down into the center of the bath and pushed over the side walls of the submerged water chamber. The control of the oil temperature is within $\pm$ 0.1° F.

An annular water chamber, 16″ outside diameter and 5″ high, which is made of heavy gage tinned copper, is set in the oil bath. This chamber with a water layer 3″ deep contains a series of baffles so constructed that the air takes a spiral path as it travels over the water surface. A reservoir of one gallon capacity and a constant leveling device set in the bath maintain the water supply. The one gallon oil-can mounted on the bath is for filling the reservoir, which is below it, without interfering with the operation of the leveling mechanism.

The air passes from the saturating equipment at D and then through a horizontal insulated pipe E to be seen under the working chamber in Fig. 3. This pipe contains two electric heaters, each with a maximum capacity of 500 watts, and one electric heater with a maximum capacity of 1,000 watts. This last heating unit is seldom used except for quickly raising the temperature to that desired. The air is heated in this preheater to the temperature at which it is to be used and passes upward to the inside of the working chamber.

Working Chamber.—The inside of the working chamber WC is shown in Fig. 4. The cylindrical inner chamber, about 18″ in diameter and 18″ high, is made of heavy gage copper and provided with a door containing a window. The samples under test hang from nichrome rings at the ends of 18 horizontal rods G which are arranged radially about the air inlet pipe and revolve about it four times a minute. The motor for rotating the sample supports may be seen on the top left hand side of the working chamber in Fig. 3.

Air of the desired temperature and relative humidity enters the inner chamber F at the top through the central vertical standpipe, passes downward over the samples G and out through a passage around the intake pipe L. Recirculation is provided by a connection between L and A.

The inner chamber is surrounded by an air jacket H as shown in Fig. 4. This air jacket is surrounded by ¼″ of transite and 2″ of fibre board, the exterior surface being made of heavy gage sheet iron. The working chamber is rectangular, 26″ by 26″ by 26″ inside dimensions. It is supported by angle iron base shown in Fig. 3.

The air jacket is heated by three sets of electric plug-in heaters placed respectively at the bottom, center, and top (Fig. 4). The bottom and center heaters each consist of two 660-watt plug-in units connected in series

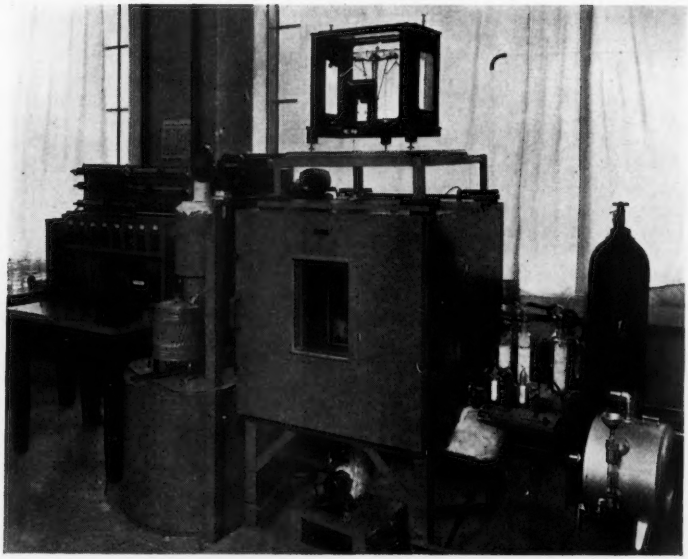

Fig. 3.—General view of the equipment.

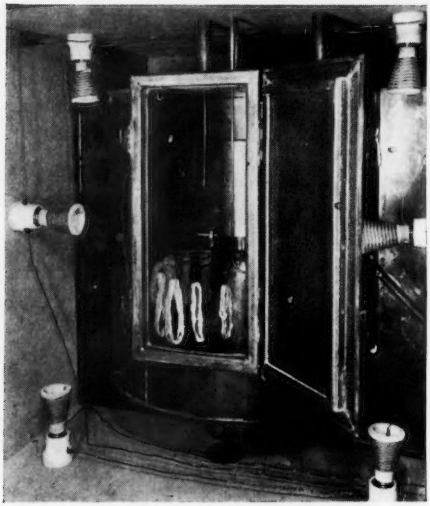

Fig. 4.—Inside of working chamber.

to consume a maximum of 330 watts. The top heaters with a maximum of 330 watts are connected with the automatic control system consisting of a mercury thermoregulator and relay. During an experimental run sufficient heat is applied to the air jacket by the bottom and center heaters to bring the temperature within a few degrees of the temperature desired, the remaining amount of heat being supplied by the automatic control system. The air in this jacket H is circulated by withdrawing it from one side by means of the blower K shown at the bottom in Fig. 3 and blowing it into the other side. The air returns over a partition which separates the two sides and extends to within a few inches of the top of the air jacket.

The temperature of the working chamber can be controlled within $\pm$ 0.4° F. for the range 96° F. to 300° F. Thermocouples are placed at the top and bottom of the working chamber to indicate any changes of temperature. The temperature of the air is recorded continuously during a test by a resistance type recording thermometer, not shown.

Windows in the inner and outer chambers make it possible to see the samples when transferring them by means of J from the supports to a nichrome wire which extends into the working chamber from the bottom of the balance pan. This wire passes downward from the balance through a heated glass cylinder, through which dry air is passed, and through an iris diaphragm. When a weighing is to be made, the rotation of the samples is stopped, the sample is transferred to the rod, and weighed. This takes only 10 to 15 seconds with the magnetically damped balance provided. With the above arrangement no difficulty was experienced from the rise of warm air about the wire or from the condensation of moisture on it.

The air from the inner chamber passes out through L to which a gas meter may be attached, when flow measurements are desired. However, if the air is not recirculated, relative humidities above 65% at temperatures up to 212° F. are not practicable. By recirculating the air from the outlet L of the working chamber to the blower A it is possible to obtain approximately a relative humidity of 90% at 212° F. with an airflow of 2½ cu. ft./min. It was necessary to provide proper insulation and a heater for this return duct to reduce condensation of moisture to a minimum. This return duct is not shown in any of the figures. It is located behind the working chamber.

The table to the left shown in Fig. 3 serves as a switch-board and holds the electrical control equipment. Four variable transformers for regulating some of the heating circuits are mounted on the table. To the right of them is a galvanometer beside the standard resistance box for reading thermocouples. Above the transformers are two relays which are in the automatic temperature control circuits. Above the switches are slide wire resistors for the manual regulation of some of the heaters and motors.

Sampling Unit.—The relative humidity in the working chamber may be determined gravimetrically by means of a sampling unit SU shown to the right of the working chamber in Fig. 3. Air containing moisture is withdrawn from the working chamber, the moisture being adsorbed by the $Mg(ClO_4)_2 \cdot 3H_2O$ in the drying tubes. The amount of moisture is determined, and the relative humidity is calculated from a knowledge of the temperature in the working chamber, the weight of the moisture, and the volume and temperature of the air analyzed. The volume of air is measured by means of a wet-gas meter N of ¼ cu. ft. capacity per revolution, with an accuracy of ½ of 1%. The temperature of the air varies from

70° F. to 80° F. (room temperature). This gravimetric method gives the relative humidity to within $\pm 0.5\%$ relative humidity.

It was found necessary to provide a means of driving over into the drying tubes any moisture that may condense between the equipment and the drying tubes, particularly at the higher temperatures and higher relative humidities. This was done by placing a glass trap between the equipment and the drying tubes. After a run is made this condensed water was then driven into the $Mg(ClO_4)_2 \cdot 3H_2O$ with dry air. The dry air is produced by taking compressed air from a tank and passing it over sulfuric acid, $Mg(ClO_4)_2 \cdot 3H_2O$, and P_2O_5.

Constancy of Relative Humidity and Temperature

The constancy of the relative humidity in the working chamber under operating conditions may be judged from Table 1. These results are typical of the experiments that have been made with the equipment while in operation for the past two years.

TABLE 1

Time	Relative humidities at 96° F, with recirculation Percent
Beginning	92.3
End of 24 hrs.	92.3
End of 48 hrs.	92.1
End of 72 hrs.	92.5
End of 96 hrs.	92.3
Average	92.3

Time	Relative humidities at 96° F, without recirculation Percent
Beginning	62.9
End of 12 hrs.	63.3
End of 24 hrs.	63.0
End of 36 hrs.	63.2
End of 60 hrs.	63.1
Average	63.1

Time	Relative humidities at 219° F, with recirculation Percent
Beginning	79.2
End of 4 hrs.	79.0
End of 8 hrs.	79.4
End of 24 hrs.	79.0
Average	79.2

Time	Relative humidities at 219° F, without recirculation Percent
Beginning	15.8
End of 4 hrs.	16.2
End of 8 hrs.	16.0
End of 24 hrs.	16.4
Average	16.1

Acknowledgment

Acknowledgment is made to Dr. A. C. Walker, Chairman, and Dr. Frederic Bonnet, member, Administration Committee for Drying Research, U. S. Institute for Textile Research, and to W. D. Appel, of the National Bureau of Standards, chairman, Research Council, U. S. Institute for Textile Research, for valuable suggestions in the development of the constant humidity and constant temperature equipment.

Behavior of Gelatins and Glues in Size Baths at Low Concentrations

By WILLIAM E. YELLAND *

A Research of U. S. Institute for Textile Research, Inc.

Summary

During a study of the slashing of rayon warps for pile fabrics size mixes which contained less than 1% size material were used. Under these circumstances it was observed that the amount of size deposited on the yarn and the resultant weaving efficiency of the warp were affected not only by the concentration of material in the size mix but also by the viscosity of the size bath. When used at the same concentration, materials of higher gel strength produced size baths with higher viscosity and deposited more size on the yarn than materials of lower gel strength. When the concentrations were adjusted so as to produce size baths with the same viscosity, the size absorption was related to the concentration. The weaving efficiency, although not directly proportional to the amount of size on the yarn, was appreciably affected by changes in the amount of size absorbed.

Changes in the temperature of the size bath led to variations in size viscosity. These produced fluctuations in size absorption and were followed by changes in weaving efficiency. At these low concentrations no differences in size distribution on the yarn were observed.

Introduction

IN a previous article (*Tex. Rsch.*, IX, 11, 409–17, 1939) the behavior of glues and gelatins in size mixes at concentrations close to 3% was discussed. Shortly after this phase of the work had been completed an opportunity † was presented for the study of the behavior of similar materials at much lower concentrations, namely less than 1%, in the sizing of pile warps used in the manufacture of velvet fabrics. During the weaving of these materials the warps which form the pile are subjected to much

* Dr. Yelland was director at Massachusetts Institute of Technology of the filament viscose rayon phase of the warp sizing research from Jan. 1, 1936, to Sept. 30, 1938, and is now with Corn Products Refining Co., Research Laboratory, Edgewater, N. J.

† This opportunity was presented through the courtesy of Cheney Brothers, South Manchester, Conn. The author wishes to express his sincere appreciation for the experimental facilities provided by the mill and for the whole-hearted co-operation of the mill staff during the experiments.

less friction in the loom than the ground warps and ordinary warps in general. Consequently less protection is required and a much lighter size can be used.

Materials.—The yarn used was 125 denier 50 filament bright viscose rayon. There were available three size materials, A, B and C, covering the range from edible gelatin to technical glue. The characteristics are reported in Table 1.

TABLE 1

Sample	A	B	C (Edible)
Moisture Content	12.6%	11.8%	11.8%
Ash Content	3.2%	2.0%	1.1%
Gel Strength (*i.e.*, Bloom number in 6.66% concentration)	97 grams	108 grams	243 grams

From the table it will be seen that C would be classed under the usual nomenclature as a high grade edible gelatin, A as a glue or lower grade gelatin-glue, and B as an intermediate product.

These materials were first used in the same concentration, so the three size mixes had different viscosities (see Table 2). Later the materials were made up and used at different concentrations such that the size mixes had practically the same relative viscosity.

In all experiments the same softener was used in the same concentration. This is not general practice but it was desirable here in order to eliminate one set of variables. The softener was a typical mixture containing a sulfonated oil, glycerin and water.

Procedure

The yarn was slashed on a five-can rayon slasher with the usual manual controls. The warps from this experiment were then woven consecutively in one loom and complete records of the warp breaks were taken. From these were calculated the time per 1,000 picks required by the weaver for tying up breaks and defects in each pile warp only. Thus for each pile warp a figure was obtained which expressed the weaving efficiency of that warp. Since these figures were calculated from the actual number of breaks in a pile warp, and did not include any time required for fixing breaks or defects in the ground warp and filling, they afforded a better evaluation of the sizing of the pile warp than the usual weave room efficiency figures. In this case the lower the number the better was the weaving efficiency of the warp.

Effect of Gel Strength in the Same Concentration.—The viscosities of the size mixes containing equal amounts of A, B and C were related to the gel strengths, A having the lowest gel strength and viscosity and C the highest. In the article previously mentioned it was pointed out that the higher the viscosity of the size mix the more size was deposited on the yarn. This is confirmed in these experiments, as mixes No. 2 and No. 3 both deposited more size on the yarn than No. 1. The weave room efficiency was not directly proportional to the amount of size on the yarn. By comparison with standard warps each warp wove well. But of the three No. 2 was

considered best, No. 1 worst, and No. 3 intermediate in weaving efficiency (see Table 2).

TABLE 2

Size	Concentration	Size Mix No.	Viscosity of Size Relative to the Viscosity of Water at 60° C.	Size on Yarn	Weaving Efficiency
A	0.64%	1	1.18	1.11%	.106
B	0.64%	2	1.27	1.28%	.039
C	0.64%	3	1.28	1.57%	.070

Hence the use of higher grades of gelatin, in the same concentration in the size mix as the low grade material, resulted in an increase in the amount of size on the yarn and an improvement in the weaving efficiency.

Effect of Gel Strength at the Same Viscosity.—Gelatins B and C were also used in lower concentrations such that the viscosities of the resulting size mixes, Nos. 4 and 5, were practically the same as the viscosity of No. 1 (see Table 3). In the case of C the amount of size deposited on the

TABLE 3

Size	Concentration	Size Mix No.	Viscosity of Size Relative to the Viscosity of Water at 60° C.	Size on Yarn	Weaving Efficiency
A	1.64%	1	1.18	1.11%	.106
B	0.48%	4	1.16	1.29%	.215
C	0.32%	5	1.18	0.71%	.67

yarn was much less than before and the weaving efficiency was very poor. With B, practically the same amount of size was deposited on the yarn as at the higher concentration, but for some unknown reason the weaving efficiency was much less.

Thus, the high grades of gelatin cannot be used successfully in concentrations much less than 0.64% on this type of work, for although the viscosity of the less concentrated mixes is the same as that of a higher concentration of low grade gelatin, not enough size is deposited on the yarn to protect it during weaving. Any gain from the use of higher grade materials on this kind of warp must therefore be looked for in a gain in weaving efficiency and not in a saving in size material itself.

Although not enough experiments were available for conclusive proof, it would appear that the intermediate grade of material was better for this type of work than either the high grade edible gelatin or the low grade glue.

These experiments illustrate the importance of size mix viscosity. In evaluating size materials it is essential to use them under optimum conditions. This can be done only by proper choice of concentration *and* viscosity so as to deposit on the yarn the amount of size which has been found necessary for good weaving under the conditions existing in that particular weave room. To use two size materials at the same concentration only does not necessarily constitute a fair trial.

Effect of Temperature in Sizing.—The viscosity of a size mix, especially of glues and gelatins, is related to the temperature of the size, the higher the temperature the less viscous the size. Thus changes in temperature cause changes in size viscosity and in the amount of size taken up by the warp.

TABLE 4

Temperature	Relative Viscosity of Size	% Size on Yarn	Weaving Efficiency
160° F.	1.06	0.93	.045
140° F.	1.17	1.46	.027
120° F.	1.40	1.00	.120

Table 4 illustrates this effect of temperature change. The standard temperature for sizing this type of warp in this mill was 140° F. Under the slashing conditions present there, temperatures higher or lower than 140° F. caused *less* size to be taken up by the warp and resulted in *decreased* weaving efficiency.

The relationship of size absorption to temperature may be affected by other factors. So the optimum sizing temperature, in this case 140° F., will not be the same from mill to mill. When once that temperature has been determined in any mill, efforts should be made to maintain it as nearly constant as possible, as it is evident that variations in size box temperature are bound to lead to variations in size application, which in turn will cause irregularities in weave room efficiency.

Size Distribution.—The size distribution was studied according to the method given in a previous article (*Tex. Rsch.*, IX, 8, 285–91, 1939).

No differences were observed between the behavior of the high and low grade materials in these low concentrations. All the size mix viscosities were so low that the sizes penetrated well between the filaments into the interior of the yarn. There was apparently no tendency to form a film around the outside of the yarn. Many individual filaments were more or less completely surrounded by very thin size films.

The small amount of size present on the yarn made it impractical to obtain satisfactory photomicrographs for illustrative purposes.

Abstracts

Committee on Abstracts and Bibliography:
E. R. Schwarz, Chm., Dr. E. J. Saxl, C. H. Clark.

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Address, C. H. Clark, Sec., 65 Franklin St., Boston, Mass.

I. Fibres (Synthetic and Natural) and Fibre Analysis

Cellulose Hydrate Filaments: Deformation and Structure. P. H. Hermans. *Kolloid-Z.*, 1939, V. 88, P. 172–82; abs. in *J. T. I.*, Jan. 1940, P. A45.

The supposed micellar structure of celluose hydrate is discussed on the basis of previous results and with the help of a structural model that closely resembles that of Kratky. On the assumption that displacement of the micelles is difficult in the longitudinal direction but relatively easy in the transverse direction, a mathematical relationship between load/extension and molecular orientation is derived from a consideration of the deformation of a unit cube. A load/extension curve is calculated for the Kratky model that agrees qualitatively with that found experimentally for isotropic cellulose filaments. The theory is finally put to quantitative, experimental test; the results for swollen filaments are in good agreement and those for dry filaments in fair agreement with the theory. (C)

Cotton: Fineness and Maturity of. F. T. Peirce and E. Lord. *J. T. I.*, Dec. 1939, P. T173–T210.

The paper is chiefly concerned with the relation between hair-weight per centimetre and immaturity as measured at the Shirley Institute, and their interpretation in geometric terms more useful for general and fundamental studies. Hair-weight depends on both the perimeter and the degree of thickening, so for the purpose of comparing cottons in a character more nearly related to the perimeter alone, the paper develops the conception of a "Standard Hair-weight," which is the hair-weight the cotton would have

attained had it grown to a defined standard of maturity. A formula for standard hair-weight is developed empirically by testing samples of one strain of cotton picked at various stages of its growth.

As a physical relation is assumed in using this formula on individual values, affected by varying errors of determination, the crude regression line is not adopted but is corrected by a novel method of estimating the "true" relation. The treatment of the subject is essentially statistical, as the measurements are affected by sampling and other errors, arising from the great variability of cotton hairs and the limited precision of practical testing methods. A complementary study was made of 15 cottons, ranging from the finest to the coarsest available, which were examined in microscopic section and by the stapling test. The degree of thickening is determined geometrically and related to the immaturity test by a formula similar to that for the effect of maturity on hair-weight. An estimate is made of the specific volume of the cell wall and of the ratio of the mean square perimeter to the standard hair-weight. The results of the stapling test can thus be converted into geometric quantities describing the mean size and shape of the hairs.

Sectional measurements also serve to show the variations between individual hairs. The distributions of perimeter and thickening within samples of cotton are analyzed, and the relation of the latter to the three classes of the immaturity test is determined. Length and value are related more simply to the inverse of the standard hair-weight. To facilitate the study of these relations (deferred to another paper) the "Intrinsic Fineness" is defined as an inverse measure of the standard hair-weight, in units directly comparable with yarn counts and with hair dimensions. To obtain a direct measure of fineness, the various measures of diameter are examined with regard to their proportionality to the square root of the standard hair-weight and their independence of immaturity. Of the several measures, ribbon-width, swollen diameter, etc., the mean projected diameter appears the most useful measure (inverse) of fineness, though certain errors are indicated for further investigation. (C)

COTTON: PRODUCTION OF WHITE EGYPTIAN. Fouad Abaza Pasha. *Cotton (Manchester)*, 1939, V. 45, No. 2184, P. 18; abs. in *J. T. I.*, Dec. 1939, P. A752.

About two years ago the Royal Agricultural Society of Egypt put on the market a new variety of cotton called "Bahtim Abiad," *i.e.*, Bahtim White, which is almost equal in whiteness to Peruvian Tanguis but is finer, longer and stronger than Tanguis. It is classed among the medium staples of Egypt, *i.e.*, in the same category as Giza 7, and it now sells on Giza 7 contracts at a premium slightly below that of Giza 7. An important feature of this cotton is its remarkable earliness. The plant is a small tree with good fruiting nature and responds well to nitrogenous fertilizers but is susceptible to wilt. (C)

ETHERS AND ESTERS OF CELLULOSE AND THEIR COMMERCIAL APPLICATIONS WITH PARTICULAR REFERENCE TO THE TEXTILE INDUSTRY. H. Rath. *Klepzig's Text.-Z.*, 1939, V. 42, No. 30, P. 1–2; No. 32, P. 1–2; abs. in *C. A.*, 1940, V. 34, Col. 1171.

A discussion of the constitution soly., prepn. and application of cellulose esters and ethers. (C)

GERMAN STAPLE-RAYON INDUSTRY: RESEARCH IN THE. Ludwig Geisser. *Klepzig's Textil.-Z.*, 1939, V. 42, No. 30, P. 1–2; No. 32, P. 1–2; abs. in *C. A.*, 1940, V. 34, Col. 1181.

A survey. (C)

II. YARNS AND FABRICS

THROWING RAYON CREPE YARNS. W. F. Macia. *Rayon Text. Mo.*, 1939, Oct., P. 60–2; Nov., P. 55–7.

Discusses technological progress, advance in manufacture and present status. (C)

VINYON: A NEW TEXTILE FIBRE. F. Bonnet. *Am. Wool & Cotton Rptr.*, Feb. 1, 1940, P. 13–4, 22; *Am. Dye. Rptr.*, Mar. 4, 1940, P. 116–20.

Paper presented at meeting, New York Section, A. A. T. C. C., Jan., 1940. (C)

WOOL CARBONIZING. *Wool Record*, 1940, V. 57, P. 144–5, 147; abs. in *J. T. I.*, Mar. 1940, P. A138.

A general review of the carbonizing process with special reference to the possible uneven distribution of acid caused by uneven squeezing or hydro extracting. It is suggested that except for the coarsest wools carbonizing temperatures should not exceed 85% and the advantage of using stronger acid at lower temperatures is stressed. Damage is best detected by microscopic examination but the Pauly test is also useful. In neutralization of residual acid sodium carbonate should be used with care, and a preliminary washing off in water is recommended. (C)

WOOL: CONTROLLED SCOURING OF. Howard P. Galloway. *Text. Wld.*, Jan. 1940, P. 73–4.

New system of instrument control makes possible improved quality of stock with lowered costs. (C)

WOOL: DESTRUCTION OF. *Wool Record*, 1940, V. 57, P. 100–1; abs. in *J. T. I.*, Mar. 1940, P. A151.

A survey of the various agencies, *e.g.*, alkali, acid, oxidizing agents such as hydrogen peroxide and chlorine, reducing agents, *e.g.*, sulphur dioxide, micro-organisms, sunlight, which may damage wool with an account of methods whereby these destructive agencies may be controlled. (C)

WOOL: ENZYME TREATMENT TO DIMINISH SHRINKAGE. Wool Industries Research Assoc. (Leeds), H. Phillips and W. R. Middlebrook. B. P. 513,-919 of 21/4/1938: 25/10/1939. *J. T. I.*, Jan. 1940, P. A44.

A process for the treatment of woolen materials for the purpose of diminishing shrinkage consists in subjecting the material to the action of a solution of a protease of animal or vegetable origin, the solution containing also an enzyme accelerator and an electrolyte adapted to maintain the pH value of the solution between 8.5 and 10.0. Suitable solutions are (1) a solution of trypsin containing sodium sulphide and (2) a solution of papain containing sodium bisulphite as activator. The papain solution is

preferable to the trypsin solution for the treatment of woolen materials containing silk. (C)

X-Ray Studies of New Types of Italian Rayons. Mario Milone. *Chim. e ind.* (Italy), 1939, V. 21, P. 567–71; abs. in *C. A.*, 1940, V. 34, Col. 632.

X-ray studies of Italian rayons show that the new types owe their higher strength to their internal structure, the mols. being arranged in lines parallel to the axis of the fibre and consequently are strongly stretched during formation. An index of parallelism is proposed, which can be readily detd. from the X-ray diagram and which is a very good index of quality of the fibre. (C)

III. Chemical and Other Processing (Not Otherwise Classified)

Alkaline Peroxide Solutions: Stability of. J. M. Martremont. *Rev. Gen. Tein. Imp. Blanch. App.*, 1939, V. 17, P. 531–7; abs. in *J. Soc. Dyers Col.*, Feb. 1940, P. 80.

Precipitated stannic acid has the disadvantage that it remains in suspension and relatively large quantities are necessary on account of its feeble action. On the other hand, alkali stannates, even in small quantities, give good results, particularly under conditions which prevent precipitation of tin, even on prolonged keeping, *e.g.*, by dissolving sodium stannate in a hydrogen peroxide solution at pH 4–5. The stabilizing action of sodium pyrophosphate when used in conjunction with sodium stannate is definitely superior to that obtained with sodium pyrophosphate alone. Sodium stannate retards decomposition of hydrogen peroxide solutions at 90–100° C., and can be used, therefore, to increase their bleaching action, provided that the pH is kept below 6. Water-soluble salts of ester acids of pyrophosphoric acid and long-chain aliphatic alcohols, *e.g.*, sodium lauryl pyrophosphate or alkaline earth salts of certain alkyl sulphates, *e.g.*, the magnesium salt of sulphonated oleyl alcohol, are added to hydrogen peroxide to prevent its decomposition during bleaching and to increase its wetting action. Soaps, particularly olive oil soaps, have a marked stabilizing action on hydrogen peroxide, but are less important than the stabilizers already mentioned. (C)

Cellulose Ester and Ether Aeroplane Dopes: Effects of Solvents, Diluents and Plasticizers. F. W. Reinhart and G. M. Kline. *Ind. Eng. Chem.*, 1939, V. 31, P. 1522–9. (C)

Cotton Rayon Mixtures: Bleaching. H. Joubert. *Bull. Soc. Ind. Rouen*, 1938, V. 66, P. 349–66; abs. in *J. T. I.*, Dec. 1939, P. A773.

Methods of bleaching cotton and methods of testing for damage to the material, particularly viscosity and boiling index determinations, are reviewed and the application of these methods to cotton-rayon mixtures is studied. The results of measurements of strength and extensibility, viscosity, boiling index and loss in weight of a mixture fabric containing 16% viscose staple fibre after bleaching treatments comprising (1) pressure boil, chlorine treatment and hydrogen peroxide treatment, (2) open alkali

boil, chlorine treatment and hydrogen peroxide treatment, (3) hydrogen peroxide bath, chlorine treatment and a second hydrogen peroxide bath, (4) two hydrogen peroxide baths, and (5) chlorine treatment followed by a hydrogen peroxide bath are given and compared, and the results of determinations of the loss in weight of samples of Vistra in these various bleaching treatments are also given. (C)

DAMAGING EFFECT OF FAT SOLVENTS IN THE DEGREASING OF CRUDE WOOL BY BENZINE AND TRICHLOROETHYLENE: CAUSES OF. E. Langer. *Spinner u. Weber*, 1939, V. 57, No. 21, P. 35–6 (through *C. A.*, 1939, V. 33, Col. 9654); abs. in *J. T. I.*, Feb. 1940, P. A86.

In degreasing, the solvent should not be in contact with the wool at 45° for longer than 20–30 min. Wool should never be degreased completely; three baths should be used with 40, 20 and 10% fat content so that the wool retains 0.5–0.8% fat; no steam should be employed for the removal of the solvent or for drying; the temperature of the moist air should not exceed 45° C. Organic solvents give the product a better appearance than an aqueous wash, make it possible to recover the wool fat and wool suint and render it unnecessary to use soaps, soda, etc. Wool fat and wool solvent can be recovered completely by extraction. (C)

DYEING CELLULOSE ACETATE RAYON WITH ACID AND DIRECT DYES. P. M. Heertjes, C. Vogelesgang, and H. I. Waterman. *Chim. et Ind.*, 1939, V. 42, P. 155–65T; abs. in *J. Soc. Dyers Col.*, Mar. 1940, P. 143. (C)

WOOL PRINTING: TECHNIQUE OF. P. Merey. *Teintex*, 1939, V. 4, P. 611–8; abs. in *C. A.*, 1940, V. 34, Col. 1178.

Wool can be printed best on wooden rolls having the design in relief made of wood, Cu or stereo-metal. M. discusses methods of bleaching, degreasing, singeing and other steps necessary for prepg. the wool for printing. Considerable detail is included on screen, plate and roll printing of wool. (C)

IV. RESEARCH METHODS AND APPARATUS

ACCELERATED LIGHT FASTNESS TEST IN USE AT THE SHIRLEY INSTITUTE. H. Hunter. *J. Soc. Dyers Col.*, Feb. 1940, P. 64–7.

The high intensity arc, when its light has been passed through glass, to remove the short wave ultra-violet radiation, gives light which in quality very closely resembles daylight, and in intensity may be made to exceed that of noon summer sunlight twenty fold. The equipment now in use at the Shirley Institute of the British Cotton Industry Research Association can test 16 dyeings (32 exposed samples) of the highest commercial light fastness in a week of five days at six hours per day, whereas a plain carbon arc of the fadeometer type working all day and all night for five days a week requires about four weeks for the same purpose, while the exposure to daylight required would be more than a year. The drawback of the method is its cost. The first cost is not very greatly in excess of that of the fadeometer, but the running costs—carbons and electric power and the fact that it requires the full attention of an operator—are very much higher. For this reason it is not likely to become a generally available testing

method, but it is considered that its speed and accuracy justify the maintenance of at least one equipment of its kind at a central testing station. (C)

ALLWÖRDEN REACTION: CAUSE, NATURE AND SIGNIFICANCE OF. Curt Müller. *Klepzig's Textil-Z.*, 1939, V. 42, P. 329–33; abs. in *C. A.*, 1940, V. 34, Col. 1184.

A crit. discussion of the value of the Allwörden reaction (*C. A. 10*, 1436). The bubbles of the Allwörden reaction are caused by the cells of the scales. The character of the bubbles is described as well as the behavior toward alkalies, acids and mech. factors and the formation of the bubbles by osmotic forces, whereby the wall of the bubble acts as a true membrane with selective permeability. The Allwörden reaction is not a generally applicable testing method. 13 references and 6 photomicrographs. (C)

AMOA TEST FOR ANALYSIS OF MIXTURES OF SISAL AND MANILA. A. V. Billinghame. *Text. Mfr.*, Mar. 1940, P. 118, 124.

An improved staining test. (C)

ARTIFICIAL FIBRES PREPARED FROM HYDRATED CELLULOSE AND FIBRES FROM NATURAL CELLULOSE: SIMPLE AND RAPID METHOD FOR THE QUANTITATIVE SEPARATION OF. Karl Schwertassek. *Angew. Chem.*, 1939, V. 52, P. 700–1; *Kunstseide u. Zellwolle*, 1939, V. 21, P. 422–6; abs. in *C. A.*, 1940, V. 34, Col. 1171.

The method consists in treating the fibres with cold 10% NaOH soln. contg. some wetting agent. The soaked fibre gels are pressed by rollers on a fine screen where the artificial fibres break down and pass through owing to their lower mech. resistance and the natural fibres remain as their resistance even in the soaked condition is fairly high. Acetylcellulose fibres must be removed prior to the test by soln. in acetone. Wool loses considerable wt. and the method is not applicable to it in the present state. (C)

CALIBRATION OF SILK POROSITY METERS. J. Teres and Philip Sharnoff. *Rayon Text. Mo.*, Oct. 1939, P. 69–70. (C)

V. PURE SCIENCE, ECONOMICS AND MISC.

PROTEINS: STRUCTURE OF. L. Pauling and C. Niemann. *J. Am. Chem. Soc.*, 1939, V. 61, P. 1860–7.

The authors have examined the X-ray arguments and other arguments advanced in support of the cyclol hypothesis, and conclude that there is no evidence whatever in support of it, but that there is strong evidence in support of the contention that bonds of the cyclol type do not occur at all in any protein. On the other hand, the present authors consider that Emil Fischer's polypeptide chain structure of proteins, with hydrogen bonds and other interatomic forces (weaker than those corresponding to covalent bond formation) acting between polypeptide chains, parts of chains, and side-chains, is compatible not only with the chemical and physical properties of proteins, but also with the detailed information about molecular structure, in general, which has been provided by the experimental and theoretical researches of the last decade. Finally, the present state of the protein

problem, with special reference to polypeptide chain structures, is summarized. (C)

PROTEINS: STRUCTURE OF. (1) I. Langmuir. (2) I. Langmuir and D. Wrinch. *Proc. Phys. Soc.*, 1939, V. 52, P. 592–624; abs. in *J. T. I.*, Nov. 1939, P. A746; Dec., P. A808.

A comprehensive review of the fundamental data on protein structure. The agreement between the properties of the globular proteins and the cyclol structures proposed for them gives an adequate justification for the cyclol theory. (C)

RESEARCH ASSOCIATESHIP OF THE TEXTILE FOUNDATION AT THE NATIONAL BUREAU OF STANDARDS. Warren E. Emley. *Am. Dye. Rptr.*, Sept. 4, 1939, P. 497–8. (C)

SPECTRAL VARIATION OF THE PHOTOSENSITIVITY OF VISUAL PURPLE. E. E. Schneider, C. F. Goodeve, and R. J. Lythgoe. *Proc. Roy. Soc.*, March 16, 1939, V. 170A, P. 102–12; abs. in *Eastman Abs. Bull.*, Sept. 1939, P. 473.

The variation with wave length in the efficiency of absorbed quanta for bleaching visual purple has been measured. When the photosensitivity is compared with the scotopic luminosity curve, recalculated on a quantum basis, agreement is good except in the blue where yellow substances in the eye reduce visibility. (S)

STARCH: ELECTROKINETIC POTENTIAL AND ZYMOLYSIS. Y. P. Barmenkov. *Biokhimiya*, 1938, V. 3, P. 740–50 (through *C. A.*, 1939, V. 33, Col. 4274); abs. in *J. T. I.*, Nov. 1939, P. A738.

The electrokinetic potential and enzymic activity of starch increase with falling H-ion concentration to a maximum at pH 6.8–7.1. Starch remains electronegative in both acid and alkaline media. In 0.1 *N* aluminium chloride it becomes electropositive and resistant to amylase. Preliminary treatment with Na chloride renders starch slightly more easily fermentable, but similar treatment with Al chloride completely inhibits zymolysis. (C)

STEREOSCOPIC CALCULATIONS. B. Wright. *Phot. J.*, Jan. 1938, V. 78, P. 19–23, 35; abs. in *Eastman Kodak Abs. Bull.*, Oct. 1939, P. 506.

The author comments upon two previous papers (C. W. Wilman, *Monthly Abstr. Bull.*, 1936, V. 22, P. 524; *Phot. J.*, Aug. 1937, P. 491–96), claiming that the nearer limit of depth of subject is not necessarily limited by the position of the window. It is also maintained that the angle through which the eye turns in ranging from the near to distant points in the stereogram is of greater importance than the separation of conjugate points as between the farthest and nearest points of the picture. Perspective, relief, and depth of field in stereoscopic photorelief, and depth of field in stereoscopic photomicrography are discussed in general terms. Wilman's reply to the criticism is published. (S)

TEXTILE WASTES: TREATMENT OF. Robert S. Weston. *Sewage Works J.*, 1939, V. 11, P. 657–74; abs. in *C. A.*, 1939, V. 33, Col. 2258, 9659.

The paper begins with a brief description of the processes of bleaching, mercerizing, coloring, S dyeing, printing, and the processing of wool, silk

and rayon. Tables are given showing the chem. characteristics of the textile wastes. The following subtitles are discussed under the general heading of treatment of wastes: equalization of flow, the acid and centrifugal processes for treating wool-scouring wastes, chem. treatment which is very costly, sludge handling from chem. treatment, and biol. treatment on trickling filters, secondary cinder filters and activated sludge. For a high degree of treatment the biol. processes are preferred. (C)

URONIC ACIDS: DETERMINATION OF—IN CELLULOSIC MATERIALS. Roy L. Whistler, A. R. Martin and Milton Harris. *Text. Rsch.*, Jan. 1940, P. 109–19; *Am. Dye. Rptr.*, Jan. 8, 1940, P. 1–6.

The tensile strength, moisture, dye absorption, and viscosity in cuprammonium solution of natural cellulosic fibres are related to the presence of small quantities of pectin. In their study of this relationship the research associates of the Textile Foundation at the National Bureau of Standards found it necessary to develop a method for quantitative estimation of pectin and its constituent uronic acids. (C)

VAPOR PRESSURE OVER SOLUTIONS OF CELLULOSE ESTERS. A. Pakshver and E. Mankash. *J. Phys. Chem.* (U. S. S. R.), 1938, V. 11, No. 6, P. 864–70; abs. in *Eastman Kodak Abs. Bull.*, Oct. 1939, P. 539.

Measurements were made of the vapor pressure over solutions of cellulose nitrate in an alcohol-ether mixture and cellulose acetate in acetone and in an alcohol-acetone mixture at 10° C. to 50° C. A lowering of the vapor pressure was observed only at very high concentrations of cellulose ester, that is, above 60%, for cellulose nitrate in alcohol-ether solution, and above 70%, for cellulose acetate in acetone. (S)

VISCOSE RAYON PRODUCTION: RECOVERY OF CS_2 IN. R. L. Luaces. *Rayon Text. Mo.*, June 1939, P. 55–6. (C)

WASTES: TREATMENT OF LIQUID—FROM THE TEXTILE INDUSTRY. C. R. Hoover. *Ind. Eng. Chem.*, 1939, V. 31, P. 1352–8.

A review with 18 references. (C)

WOOL FELTING: THEORY OF. E. Justin-Mueller. *Rev. gen. mat. color.*, 1939, V. 43, P. 260–3; abs. in *C. A.*, 1939, V. 33, Col. 869, 9001.

Microscopic examn. showed beginning entanglement of the fibres even before the milling operation; during milling the fibres swell and cement themselves together, by reason of a protogel formed during the swelling. The protogel can be detected by staining various agents and by its violet-blue fluorescence in ultraviolet light. (C)

X-RAY DIFFRACTION APPLIED TO CHEMICAL ANALYSIS. Wheeler P. Davey. *J. Applied Physics*, Dec. 1939, P. 820–30.

Chemical analysis by X-ray diffraction methods is discussed under the following heads: (1) The identification of a one-component material; (2) the identification of a multi-component material; (3) the identification of a crystalline material which contains a second material dissolved in it in solid solution. (C)